Technische Hochschule Ingolstadt

Faculty of Electrical & Information Technology
Masters in AI Engineering of Autonomous Systems

Exploring Capabilities of UAVs of Human Detection for Emergency Response and Disaster Management

Scientific Seminar

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Abstract

This paper addresses the problem of human detection in emergency and disaster situations. The existing challenges in disaster-stricken areas demand a swift and efficient method to detect and assess human presence for timely rescue operations. The challenges present are related to the climatic, environmental, remote location, time delay, flight duration, techncial and communication. To tackle this issue, the study will explore the capabilities of UAVs equipped with advanced object detection systems. The primary objective is to develop an autonomous system capable of accurately detecting and scoring human presence in disaster-affected regions. By undertaking this research, we aim to contribute to the development of a robust emergency response framework, ensuring the prompt and secure assistance required in critical situations.

Index Terms - Autonomous Drones, Unmanned Aerial Vehicles(UAV), Human detection, Thermal imagers, Posture estimation, Autonomous path planning, SWARM Drone

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1 Introduction

In the case of natural hazards like earthquakes, floods and wildfires, have the potential to destroy and damage infrastructure and communication systems, which could lead to loss of life, and compel individuals to leave their residences. The aftermath of such occurrences frequently necessitates the relocation of people to more secure areas. Emergency response involves rapid, coordinated efforts to address the immediate consequences of unexpected events, aiming to save lives and safeguard property. Disaster management deals with various factors such as covering preparedness, response, recovery, and mitigation to reduce the impact of disasters and enhance community resilience. People stuck in critical situations require water, food and medical assistance. Hence, that is necessary to locate such victims. To locate and rescue humans and animals, we use trained search and rescue teams, employ technologies such as satellite imaging, utilize communication systems, and involve communities in preparedness activities. However, still we are unable to get maximum results, the reasons behind this are traditional methods, unknown locations, climate, dense forests, and unavailability of information and data communication between the SAR team and disaster victims. Moreover, improper visibility and darkness in night are vital hurdle for SAR. Thus, This research paper aims to explore the integration of Unmanned Aerial Vehicles (UAVs) with advanced object detection techniques to enhance emergency response capabilities in disaster-stricken areas. Further, to enhance the capability to rescue people this advanced computer vision technique will detect, count, and track humans intelligently. In addition to that, this information should be shared with the emergency and medical response team without time delay.

2 The Human Detection Problem in Emergency and Disaster Management

A disaster is a serious problem occurring over a period of time that causes widespread human, material, economic or environmental loss which exceeds the ability of the affected community or society to cope using its own resources.[1]Examples of natural hazards include avalanches, flooding, cold waves and heat waves, droughts, earthquakes, cyclones, landslides, lightning, tsunamis, volcanic activity, wildfires, and winter precipitation.[2] Examples of anthropogenic hazards include criminality, civil disorder, terrorism, war, industrial hazards, engineering hazards, power outages, fire, hazards caused by transportation, and environmental hazards.

2.1 Explanation of the Problem

In the situation of a disaster, the search and rescue team requires sufficient information data for instance, exact location, number of humans, availability of transport etc. to migrate them into safe site, but the circumstances are not favourable for humans to collect and provide such information to SAR team. The circumstances could be involved in heavy rain, flood, dense forest, critical temperature or fire. Visibility also affects the video output. Different demographic groups may have distinct medical needs. Children and elderly individuals, for example, might require specialized medical attention, resource allocation, and an evacuation plan. Individuals' movements may not be predictable, whether they are standing or moving in an uncertain direction. In this complex situation, expertise is required for the selection of instruments such as UGVs, UAVs, and robots. How many drones are required and how much time is needed to execute the operation are critical questions.

2.2 Unmanned Aerial Vehicles(UAV) and its Applications

Unmanned Aerial Vehicles (UAVs) are commonly referred as pilotless aircraft with the capability to fly and stay airborne without requiring any human onboard operator, providing more cost-efficient operations than equivalent manned systems, and performing cost-efficient critical missions without risking human life. Drones have emerged as valuable innovations in the last few decades because of their ability to navigate diverse environments, access hard-to-reach locations, and swiftly cover large areas makes them ideal for augmenting traditional response methods.

The given figure 1 represents various areas where drones have solved problems. The applications of UAVs extend beyond mere surveillance; they actively contribute to search and rescue missions, damage assessment, and logistics support. Their deployment aids in overcoming challenges posed by extreme weather conditions, inadequate lighting, and complex terrains. They are also used for real-time traffic monitoring. With the help of various sensors, drones assist in precision agriculture.

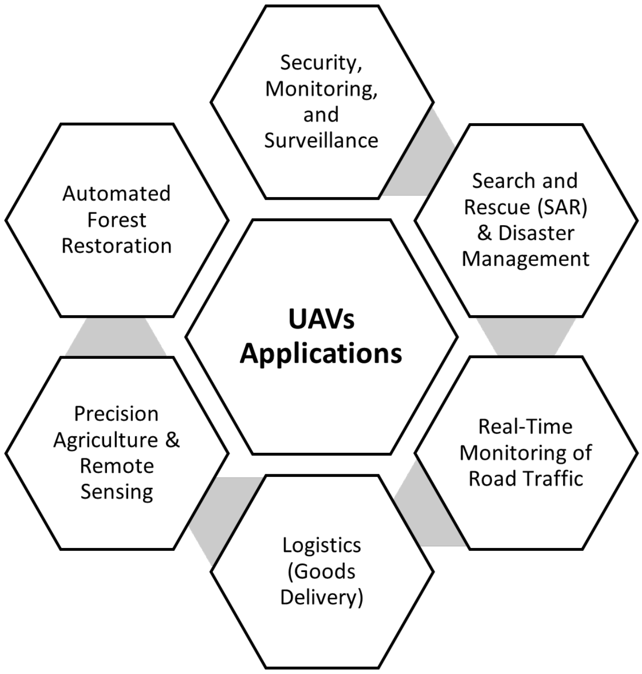

Figure 1: UAVs applications

2.3 Role of UAVs for human detection

Human detection could be successfully achieved by utilizing UAVs with advanced sensors and imaging technologies play a crucial role in enhancing the situational awareness of disaster-stricken areas, enabling more efficient and targeted response efforts.[9] Figure 2 [11]represents the flow diagram of the UAV-based surveillance process, respective stage demonstrated below in detail.

1. Drone with Camera - Live Video Feed - A multirotor drone equipped with an infrared (IR) thermal imaging camera captures live video feed in disaster-stricken areas, especially during challenging conditions like earthquakes or floods.

2. On-Board Video Analysis Using Proposed Model - The drone performs on-board video analysis using the proposed model, incorporating techniques such as k-means clustering, morphological operations, and template matching. This enables the detection of individuals in distress and the estimation of their postures.

3. GPS Location of Humans (To Central Server) - Identified human positions are determined by the drone, and the corresponding GPS coordinates are transmitted to a central server. This information is crucial for coordinating and directing rescue efforts.

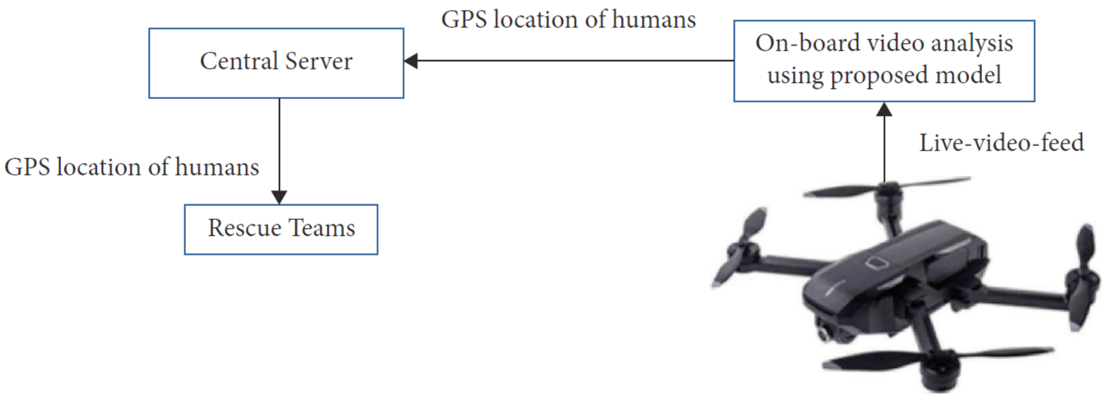

Figure 2: flow diagram of UAV based surveillance process

4. Central Server - The central server receives the GPS location data of humans detected by the drone. It acts as a hub for aggregating and processing information from multiple drones operating in the disaster area.

5. GPS Location of Humans (From Central Server) - The central server processes the received GPS data and disseminates the refined location information back to the rescue teams. This ensures that the rescue teams have accurate and up-to-date information about the positions of individuals in need of assistance.

6. Rescue Teams - Equipped with the updated GPS coordinates, rescue teams can navigate to the precise locations of individuals identified by the drone. This enhances the efficiency and effectiveness of search and rescue missions in disaster situations.

This streamlined process ensures a systematic and technologically advanced approach to human detection and rescue operations in challenging disaster scenarios.

3 Environmental and Climatic Constraints in Human Detection

3.1 Effects of Extreme Weather on UAV Performance

Constraints:- In situations of fog, wind, rain, snow, temperature and fire, the drone has its own constraints. Materials, sensors, and components have their limitations. It cannot fly in all weather conditions; hence, it is crucial to know how and when the flyability of a particular drone is high. Drone manufacturers provide various technical specifications such as wind speed, precipitation tolerance, minimum and maximum operating temperature.

Possible solution:-Technological research and advancements aimed at enhancing drone functionality, including improvements in materials and sensors, play a pivotal role in mitigating environmental constraints. These enhancements not only minimize limitations posed by adverse weather conditions such as fog, wind, rain, snow, temperature extremes, and fire but also contribute to the augmentation of drone specifications, particularly in terms of climate adaptability. Hence, the selection of proper drone parameters is vital. From this research, mentioned below 2 most preferable weather-resistance drones from the respective manufacturers. Zipline's zip model is suitable for 46 °C for maximum operating temperature; – 20 °C for minimum operating temperature; 14 m/s for maximum wind speed resistance; and 50 mm/h for precipitation tolerance. While Lockheed Martin's Indago 3.1 can survive in even – 34.44 °C for minimum operating temperature.[3]

3.2 Daylight Constraints

Constraints:- Daylight is an important factor that affects not only the drone's flyability but also the camera output. Drones having economical and standard cameras function better in visible daylight conditions. For better image quality 4K, 6K or 8K cameras could also useful, 8K is a higher resolution than 4K. Common 1080p screens have a resolution of 1,920 X 1,080 pixels. 4K screens double those numbers to 3,840 X 2,160, thereby quadrupling the number of pixels. 8K doubles the numbers again to a resolution of 7,680 by 4,320[4]. As resolution increases simultaneously image clarity and size, detail and sharpness improve, which is used for digital cinema and professional video production. However, they fail in the darkness, thus it is not suitable to detect a human in the nighttime.

Possible solution:-The problem could be solved by utilizing thermal images. Thermal imagers can detect objects that has infrared radiation, which is above -273.15 °C. Moreover, we can see through smoke, fog, and dust, so targets have nowhere to hide. Thus, we can see the targets even if they are in full darkness without any visible light during both day and night. Thermal cameras have technical specifications such as resolution, sensitivity, field of view, refresh rate, battery life and durability. Long wavelength infrared (LWIR) (8.0–14 μm) has low attenuation in air and is suitable for detecting ground objects near 300K that emit the most radiation[5]. Thus, it facilitates LWIR thermal imaging cameras to detect human activity day and night. Hence, the drone equipped with a thermal imaging camera can be used for SAR operations in hazardous areas [6, 7], but it has low resolution compared to visible light and no information of textures and colors[5, 8]. The climate and surrounding objects affect the quality of images captured by drones. Therefore, proper intelligent image processing is required to overcome the disadvantages of aerial thermal imaging and maintain its advantages.

4 Human Detection using UAVs

4.1 Human Detection and Posture Estimation

- **Importance of Human Posture Recognition:-** Recognizing human postures, such as standing or sitting, plays a pivotal role in emergency and disaster situations. In scenarios like earthquakes or floods, where individuals may be trapped or in distress, understanding their posture provides crucial information to rescue teams. For instance, identifying a person in a seated position might indicate a need for urgent medical attention, while recognizing someone standing could suggest a potential survivor awaiting assistance. Accurate posture recognition enhances the precision of rescue operations, guiding response teams to address specific needs based on the detected postures.

This method focuses on advanced intelligent image processing by utilizing a multirotor drone with an infrared (IR) thermal imaging camera for effective detection and posture estimation of individuals in challenging environments. In this approach, IR thermal imaging is employed both day and night, overcoming limitations posed by visible light images.

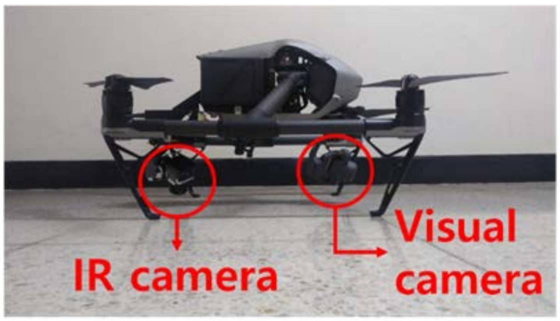

Figure 3: IR thermal camera mounted on a drone

The small drone used in this study is a DJI Inspire 2 equipped with an IR thermal camera (FILR Vue Pro R640). The thermal camera operates in the far infrared region (7.5-13.5 μm) and has a resolution of 620×540 pixels with a pixel pitch of 17μm. The drone's altitude during image capture varied, with altitudes of around 20m, 15m, and 40m for different scenarios. The study successfully captures thermal IR videos during the day and night, showcasing individuals in distress in a mountainous area.

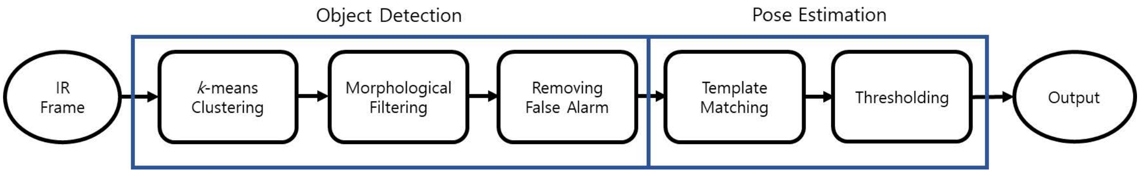

Figure 4: Block diagram of object detection and pose estimation

Figure 4[10] is a block diagram of the object detection and pose estimation in infrared images. The captured thermal image is shown in Figure 5[10]. Object detection has 3 steps k-means clustering, morphological operation, and removing false alarms based on the size and squareness of rectangular object windows (shown in Figure 6). Template matching and thresholding are further steps for Pose estimation. The experimental results demonstrate the success of this method in capturing standing or sitting individuals in thermal images captured by the drone in mountainous terrains.

Figure 5: Captured thermal image

The detection process involves k-means clustering, morphological operations, and false alarm removal based on object size and shape. For instance, the number of clusters for

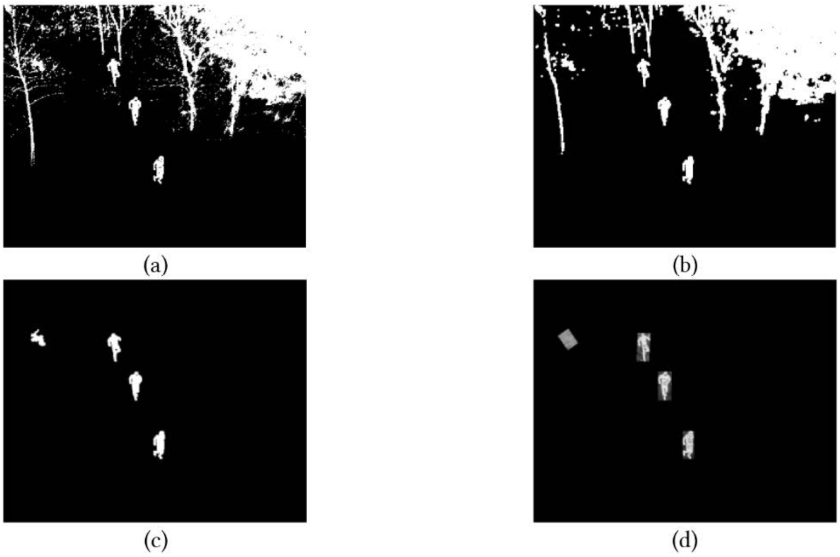

Figure 6: Detection results of Image 2: (a) k-means clustering, (b) morphological operations, (c) removing false alarms, (d) basic rectangles of detected objects

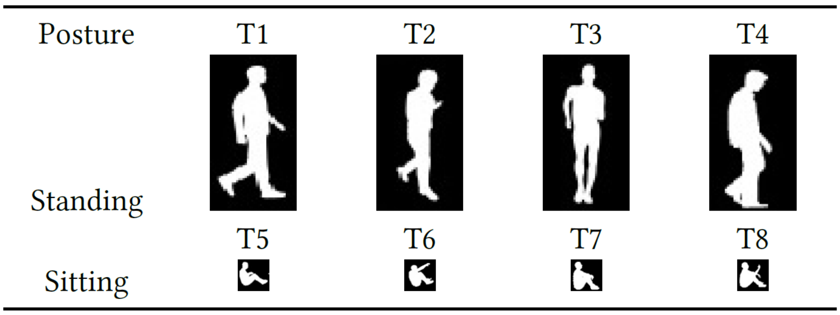

Figure 7: Templates of pose estimation

object detection was set at 4, 6, and 4 for different scenarios. The method successfully removes false alarms by varying the minimum size of the basic rectangle, showcasing its robustness. The pose estimation process (Figure 7[10]) involves template matching and thresholding, where the size of templates is scaled to match the object windows. This study pioneers the estimation of individuals' posture using a thermal imaging camera mounted on a small drone. The method's effectiveness is validated through experimental results, demonstrating successful detection and posture estimation in various scenarios.

4.2 Human detection and its action recognition

- **Importance of Human Action Recognition:-**Human action recognition, including activities like waving, walking, or running, holds significant importance in emergency response. Recognizing these actions provides critical insights into the condition and urgency of individuals in disaster-stricken areas. For example, identifying someone waving for help may prioritize that individual as a high-priority rescue target. Distinguishing between walking and running actions can indicate the urgency of evacuation or the severity of injuries. Integrating human action recognition into disaster management strategies enhances the effectiveness of response efforts, allowing rescue teams to prioritize and allocate resources efficiently based on the observed actions.

Drone technology has rapidly gained traction in the Natural Disaster Mitigation and Management sector, offering a more efficient alternative to manual video analysis for assessing disaster-stricken areas. The challenge of human identification in images captured by drones during disasters, such as earthquakes and floods, prompted the development of an innovative solution. The proposed method utilizes a camera-equipped drone and Unmanned Aerial Vehicles (UAVs) model, leveraging the YOLOv3 algorithm for human detection and action recognition.
The proposed algorithm has used single shot detector (SSD) using text detection. Figure 8[11] represents the steps involved in the proposed algorithm. The initial step is Data set collection and action selection, which is followed by Step 2 - Data Cleaning and Preprocessing. Step 3. and step 4 are Training and Testing the model respectively. Final Step is Performance evaluation.

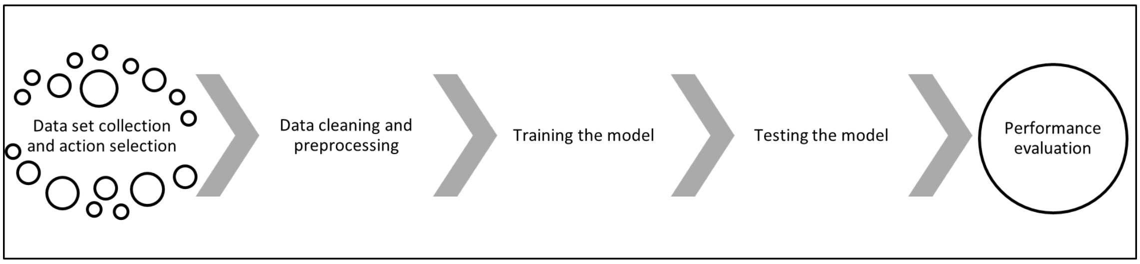

Figure 8: Steps of proposed Algorithm

In comparison to existing methods like F-RCNN, SSD, and R-FCN, the proposed model significantly expands the dataset to 1996 images with eight classes, achieving a remarkable accuracy of 94.9%. This surpasses the accuracies of faster-region-based convolutional neural networks (F-RCNN), single shot detectors (SSD), and region-based fully convolutional networks (R-FCN), which stand at 53%, 73%, and 93%, respectively. The proposed algorithm not only enhances accuracy but also excels in speed, with an average image detection time of 0.40 milliseconds. It proves to be versatile, demonstrating real-time video detection capabilities.[11]

The YOLOv3 algorithm emerges as a superior solution for human detection and action recognition, providing faster and more accurate results across a broader range of classes. The YOLOv3 deep learning technique can detect various actions of human like standing, waving, and walking (Figure 9) with a confidence score. This advancement holds significant implications for critical applications like search and rescue during natural disasters. The outcomes could be enhanced by expanding the model to include additional action classes, exploring advanced algorithms like YOLOv7, and extending the application to various disaster scenarios beyond earthquakes and floods.

Human Walking action recognition

Human Waving action recognition

Figure 9: human action recognition

4.3 Counting and Tracking of Identified Humans

- **Importance of Human counting and tracking:-**In emergency and disaster scenarios, the significance of human counting and tracking, encompassing the monitoring of individuals' locations and movements, is pivotal. This capability is paramount for expeditious search and rescue operations, aiding in the optimization of resource allocation, ensuring the safety and efficient evacuation of affected populations, identifying missing persons, facilitating coordinated response efforts, and enhancing overall preparedness through smart surveillance measures. By employing human tracking systems, authorities can make informed decisions, reduce response times, and orchestrate well-coordinated efforts during crises, ultimately contributing to more effective emergency management.

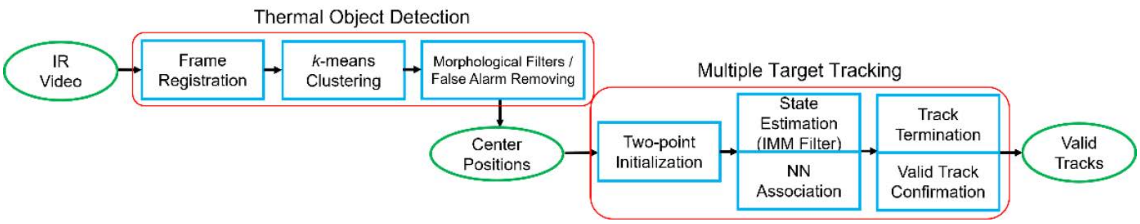

Figure 10: block diagram of the object detection and tracking

Shown Figure 10 of the tracking process begins with each video frame being registered with a reference frame to compensate for its coordinates. Thermal Object detection is then performed through a combination of k-means clustering and morphological operations, with subsequent removal of falsely detected objects based on their actual size and shape. The centroid of the segmented area serves as the measured position for target tracking. The tracking employs the Kalman or interacting multiple model (IMM) filter, initializing tracks with two-point differencing and utilizing the nearest neighbor (NN) association rule for measurement-to-track assignments. Tracks moving slower than the minimum speed are terminated by the proposed criteria. The discussion acknowledges the challenges posed by atmospheric conditions and surrounding objects, showcasing the effectiveness of proposed strategies such as coordinate compensation and track termination criteria in mitigating false alarms and enhancing tracking accuracy.[12]

In response to the COVID-19 pandemic, the research paper addresses the crucial need for effective crowd management, proposing a real-time human detection and counting system tailored for shopping malls. The system incorporates a graphical user interface and management functionalities, employing advanced deep learning computer vision techniques, specifically YOLOv3 for human object detection and classification, and the DeepSORT tracking algorithm for accurate counting. To enhance real-time computation, the pre-trained YOLOv3 is converted into TensorFlow format, utilizing a graphical processing unit. Experimental results demonstrate a commendable 91.07% accuracy, with the YOLOv3-tiny model proving more efficient for real-time processing, especially in overhead view scenarios typical of shopping mall surveillance cameras. The system's automation surpasses manual operations in terms of efficiency, effectiveness, and accuracy, making it a promising solution for crowd management. While limitations include the low resolution in certain videos, potential improvements involve deploying more advanced GPU specifications and incorporating adaptive machine learning algorithms for continual improvement in object detection accuracy.[13]

5 Performance Capability Improvement Methods

5.1 Enhance performance by proper drone type selction

- **Importance of drone type:-**Nowadays, several manufacturers provide drones with different types and parameters such as payload capacity, battery life, number of rotors, flight altitude, size, stability, maneuverability, and flight controller systems. Drones play a crucial role in providing rapid and effective response efforts in emergencies. The choice between single-rotor, multi-rotor, fixed-wing, or hybrid VTOL drones depends on the specific demands of the situation. For instance, fixed-wing UAVs with extended flight ranges are valuable for large-scale area assessments, while multi-rotors, known for their vertical take-off and landing capabilities, excel in accessing challenging terrains. The accuracy, payload capacity, and flight duration of drones are vital considerations to ensure they meet the unique challenges posed by emergency scenarios, allowing for efficient surveillance, search and rescue, and data collection to support timely decision-making and humanitarian efforts.

5.1.1 Classification of UAVs

UAV Classification Based on Rotor Number and Wing Presence:

1. Single Rotor UAVs:- Single rotor UAVs mimic helicopters, offering high carrying capacities and extended flight ranges. The centrally located main rotor maintains the drone in the air, while a smaller tail rotor controls flight direction. However, their precision in trajectory maintenance is lower than multirotor designs.

2. Multirotors:- Multirotors, like quadrocopters, hexacopters, and octocopters, gain

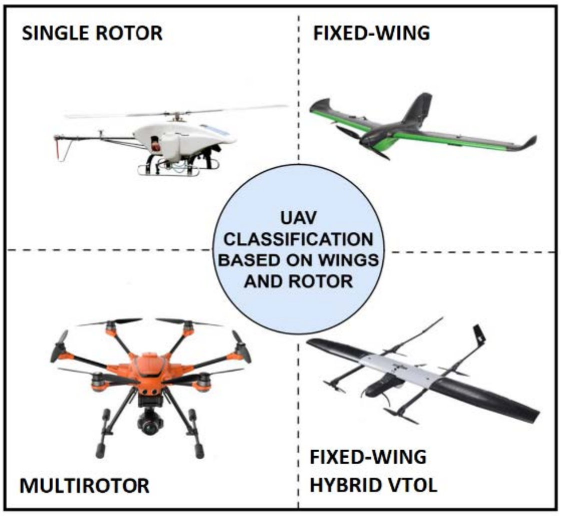

Figure 11: Classifications of UAVs[14]

popularity due to their simplicity, vertical take-off, and landing capabilities. The number of rotors affects flight stability, with hexacopters and octocopters having contra-rotating pairs for increased stability and reduced failure impact. Multirotors can be additionally divided based on the number and arrangement of engines. The most popular ones include UAVs with four (quadrocopter), six (hexacopter), and eight (octocopter) rotors. In multirotor solutions, some propellers rotate ClockWise (CW), while the others rotate CounterClockWise (CCW). Division of multirotor UAVs with contra-rotating propellers could be octocopter X and hexacopter Y.[14]

3. Fixed-Wing UAVs:- Fixed-wing UAVs resemble traditional aircraft, utilizing wings for aerodynamic lift. They consume less energy for flight, ensuring a longer range and higher payload capacity. However, their inability to hover limits applications, and they require runways for take-off and landing, making them less favorable in certain scientific and research contexts.

4. Fixed-Wing Hybrid VTOL:- A fixed-wing hybrid VTOL combines the characteristics of fixed-wing UAVs and multirotors, allowing vertical take-off, landing, and hovering. This hybrid approach leverages the advantages of both types but introduces design complexity and operational challenges. While currently under development and potentially expensive, ongoing advancements may lead to wider future adoption.

5.1.2 Comparision of UAVs

The study emphasizes that the selection of UAVs should align with prioritization criteria specific to each project, considering factors like the number of rotors, flight duration, and resistance to weather conditions. The conclusion underscores the importance of precise mission planning, communication methods, and the consideration of application-specific criteria when choosing UAVs for missions involving specialized measurement modules.

UAV type	Advantages	Disadvantages
Single rotor drone	Multitasking High flight range High payload Possibility of hovering in the air	Difficult to use Little manoeuvrability High price
Multirotor drone	Multitasking Simple operation High manoeuvrability Possibility of hovering in the air Low price	Small flight range Short flight duration High energy demand
Fixed-wing drone	Long flight duration High flight range High payload High ground coverage Resistance to external conditions	Low versatility Little manoeuvrability Large take-off and landing space required No possibility of hovering in the air
Fixed-wing hybrid VTOL drone	Long flight duration High flight range High payload High ground coverage Resistance to external conditions	Complicated operation Technology still being developed Very high price

Figure 12: Comparision of UAVs[14]

5.2 Autonomous path planning

- **Importance of Autonomous path planning:-**Time to reach the disaster location is considered an important factor; hence, minimizing the time taken by drone will improve the survivability of victims. In emergencies like search and rescue (SAR) and wildfire detection, autonomous path planning for UAVs plays a crucial role. Efficient path planning becomes vital for timely target detection, given the stochastic or unknown object locations.The autonomy of a drone's decision-making, especially in selecting the optimal path, directly impacts mission success. When the path is the shortest, the power consumption by drone will also be reduced. In other words, proper path planning increases the range of regions that have to be monitored.

Introduction of a cutting-edge framework focusing on autonomous path detection and optimizing mission time for optimized drone operations in critical scenarios, notably search and rescue (SAR) and wildfire detection.[15] The central emphasis is on augmenting mission efficiency, a pivotal aspect in scenarios where rapid target identification is imperative. The research unfolds a sophisticated strategy, amalgamating a Bayesian-inference-based path planning algorithm and a residual neural network (ResNet) for autonomous path detection utilizing image datasets captured by the drone and pertinent online datasets.
In-depth simulations and experiments underscore the efficacy of the proposed path planning algorithm, showcasing a substantial reduction in mission time compared to benchmark algorithms. The utilization of Bayesian inference aids in addressing the challenge of probabilistic target location, contributing to a holistic framework for efficient search and detection. The incorporation of ResNet in the target detection process achieves an impressive accuracy rate exceeding 91%, a testament to the robustness of the proposed system.[15]

Algorithm	Time to complete (s)	Energy consumption (KJ)
Zigzag	1024	230.4
Gaussian mixture model[16]	1060	244.8
Proposed	920	213.4

Table 1: Experimental results

Furthermore, the research delves into the practical aspects of drone deployment, using a DJI Mavic 2 Zoom with a 4k camera. Critical considerations such as power consumption are addressed (table 1), recognizing the limited onboard energy of UAVs and the need for energy-efficient operations. The study evaluates the proposed algorithm's performance through extensive simulations, illustrating its superiority in terms of mission time reduction and energy efficiency when compared to benchmark algorithms, particularly in real-world scenarios like fire detection involving Gaussian mixture.

5.3 Integration of Swarm Robotics

- **Importance of SWARM Drones:-** Swarms play a pivotal role in emergency and disaster scenarios, offering rapid and efficient responses. Autonomous UAV swarms provide extended mission durations, robust collision avoidance, and enhanced surveillance capabilities for search and rescue missions. Their adaptive design, optimization frameworks, and principles like Organic Computing enable self-optimization, efficient human-swarm interaction, and autonomous localization. In crises, swarm robotics ensures reliable performance, even in the face of individual drone failures, through hovering stability and synchronized flight mechanisms.

5.3.1 UAV swarm's collaboration system

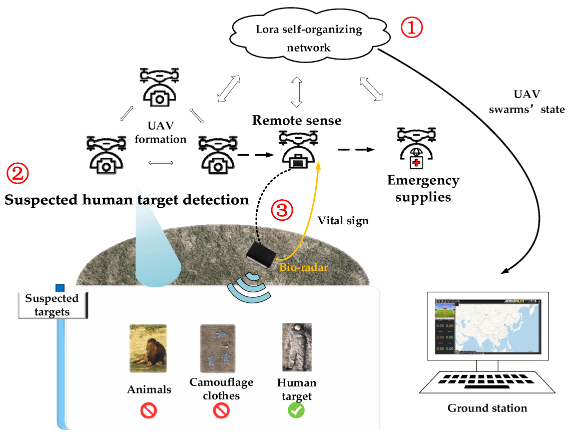

Figure 13: UAV swarm's collaboration system

A novel method is introduced for enhancing the effectiveness of unmanned aerial vehicle (UAV) swarms in SAR missions targeting injured individuals outdoors. This approach employs a mission chain-driven collaboration, addressing the challenges of limited endurance and efficiency in individual UAVs. The system integrates a long-range radio (LoRa) self-organizing network, machine vision, bio-radar, and medical emergency components. Through dual screening of human targets using various sensors, including machine vision and bio-radar, the system offers valuable guidance for ground search and rescue teams. The UAV swarm collaboration system encompasses the LoRa network for information sharing, real-time image processing through an onboard edge device, and bio-radar sensing for breath signals. The collaborative efforts of UAVs with diverse functions, depicted in Figure 2, enable the delivery of medical supplies to identified targets, showcasing a comprehensive and efficient approach to search and rescue missions.[20]

5.3.2 Mission time reduction

Autonomous path planning could be further advanced by the investigating study of a real-time path-planning solution using cooperative Model Predictive Control (MPC).[17] Employing Particle Swarm Optimization, the system adheres to international SAR directives, incorporating a coordinated turn kinematic model that considers wind effects. Initial efforts focused on single UAV solutions, emphasizing probabilistic target location and computer vision. However, the need for on-board computing and the integration of multiple UAVs became apparent.

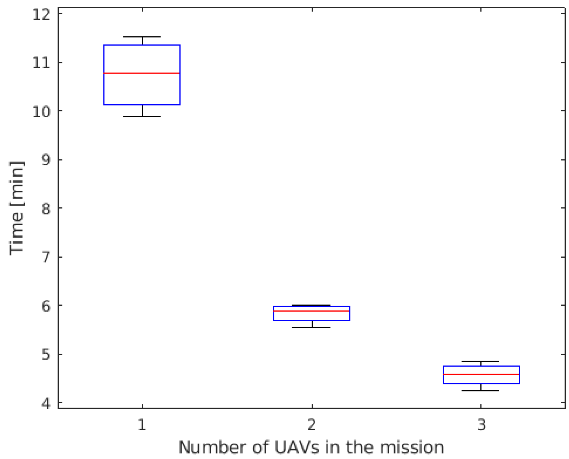

Figure 14: Time to reach 50% of Probability of success (POS)

Implemented on UAV on-board computers through DUNE navigation software, the proposed solution undergoes Software-In-The-Loop simulations with Ardupilot and JSBSim flight dynamics models. Comprehensive simulations showcase the superiority of cooperative UAVs in SAR missions. The group of three UAVs exhibits linear improvement, achieving close to 90% Probability of Success in just 20 minutes, outperforming a single UAV by 2.35 times. The impact of incorporating wind information was assessed, and even with a 20% underestimation of wind speed, the group of three UAVs achieved an

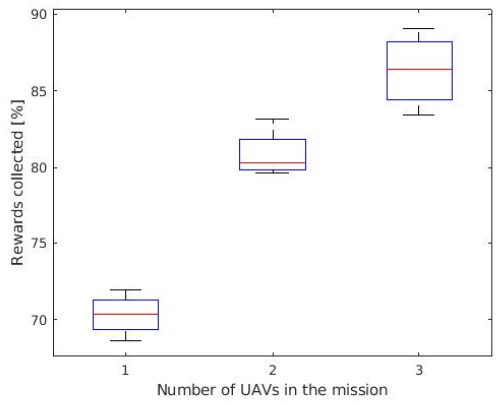

Figure 15: Probability of success (POS) in 20 min of mission.

average 4.4% higher Probability of Success in a 20-minute mission compared to scenarios without wind information. Additionally, the performance of a single UAV was measured against a conventional IAMSAR-recommended search pattern. The search utilizing the proposed solution surpassed the standard pattern within the initial 20 minutes. An added benefit is the real-time adaptability of the proposed method, enabling effective response to environmental changes and new mission directives.

5.3.3 UAV Navigation: Dynamic Pathfinding with PSO

This mehod focuses on the application of Swarm Intelligence (SI) techniques, specifically Particle Swarm Optimization (PSO) and Reynolds flocking, to address the challenges of dynamic pathfinding and collision avoidance in multi-agent Unmanned Aerial Vehicle (UAV) systems during emergency and disaster response scenarios. The proposed system, comprising PSO-based pathfinding (PSOP) and Drone Flock Control (DFC) model, demonstrates superior performance compared to traditional approaches like D* Lite. The study emphasizes the memory efficiency, computation time, and pathfinding accuracy of PSOP, showcasing its potential for real-world UAV navigation. The findings suggest that, particularly in large environments, PSOP outperforms D* Lite in terms of computation time and memory requirements. The research highlights the adaptability of PSO-based algorithms for optimizing UAV navigation, presenting implications for both autonomous vehicle control and games technology. The PSOP algorithm emerges as a promising method for enhancing the efficiency of UAV swarm navigation, crucial for time-sensitive missions in disaster management scenarios.[18]

5.3.4 Enhance flight duration

Searching range and flight duration could be increased by enhancing the battery time of the drone. For battery management, an autonomous refilling system was proposed, allowing a single drone or a cluster to swap or recharge batteries efficiently. The system demonstrated a 60-second duration for battery swapping, fully charging an exhausted battery in about 45 minutes. In the case of a swarm, this approach could be enhanced to handle multiple drones in parallel, ensuring prolonged mission durations.[19]

6 Conclusion

In conclusion, this exploration into the capabilities of Unmanned Aerial Vehicles (UAVs) for human detection in emergency response and disaster management reveals the significant potential of UAV technology in enhancing search and rescue operations. For extreme rainy, hot or cold conditions, a high-tech robust weather-resistance drone is suitable. Drone-integrated thermal cameras increase the capabilities of rescue operations even at night. Human detection and pose estimation could help identify children or adults, for specialized medical attention and resource allocation. Victim's actions and movements can be recognized and tracked. Further performance capabilities increased by proper selection of UAV type and path planning. Swarm intelligence, dynamic pathfinding, collision avoidance, and collaboration with various sensors, underscore the versatility of UAVs in addressing challenges during crises. These capabilities, when integrated into a comprehensive system, offer improved efficiency and search range by rapid response through minimizing operation time and energy consumption, and effective monitoring in dynamic environments. The findings suggest that leveraging UAVs for human detection can greatly contribute to the success of emergency operations, providing valuable insights, guidance, and support for ground teams. As technology continues to advance, further research and development in this field hold promise for enhancing UAVs' role in saving lives and mitigating the impact of disasters.

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Statutory Declaration

I certify that I have completed the work without any outside help and without using sources other than those specified and that the work has not yet been submitted in the same or similar form to any other examination authority and has been accepted by them as part of an examination. All statements that have been adopted literally or in spirit are marked as such.

Ingolstadt, August 19, 2024

Signature